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ANEXA 4

MĂRIMI GEOMETRICE

SECȚIUNEA Axele principale: 1 și 2 Axele centrale: z și y	ARIA A	DISTANȚE MAXIME până la punctele extreme de la axele principale	MOMENTE DE INERȚIE PRINCIPALE față de axele inițiale alese	MODULE DE REZISTENȚĂ $W_z = \frac{I_z}{y_{\max}}, W_y = \frac{I_y}{z_{\max}}$ RAZE DE INERȚIE $i_1 = \sqrt{I_1 / A}, i_2 = \sqrt{I_2 / A}$
1	2	3	4	5
1. Dreptunghi înclinat	$A = b \cdot h$	$z_1 = \frac{h \cdot \cos \alpha + b \cdot \sin \alpha}{2}$ $y_1 = \frac{h \cdot \sin \alpha + b \cdot \cos \alpha}{2}$	$I_z = A \left(\frac{h^2 + b^2}{24} + \frac{h^2 - b^2}{24} \cos 2\alpha \right)$ $I_y = A \left(\frac{h^2 + b^2}{24} + \frac{h^2 - b^2}{24} \sin 2\alpha \right)$ Pentru: $\alpha \neq 0^\circ$ $I_z \neq I_1, I_y \neq I_2$	$i_z = \sqrt{\frac{h^2 + b^2}{24} + \frac{h^2 - b^2}{24} \cos 2\alpha}$ $i_y = \sqrt{\frac{h^2 + b^2}{24} + \frac{h^2 - b^2}{24} \sin 2\alpha}$
2. Dreptunghi cu gol simetric	$A = h \cdot (B - b)$	$z_{\max} = \frac{B}{2}$ $y_{\max} = \frac{h}{2}$	$I_y = I_1 = \frac{B^2 - b^2}{12} h$ $I_y = I_{21} = \frac{B - b}{12} h^3$	$W_1 = \frac{B^3 - b^3}{6B} h$ $W_1 = \frac{B^3 - b^3}{6B} h$ $i_1 = \sqrt{\frac{B^2 + Bb + b^2}{12}}$ $i_2 = \frac{h}{\sqrt{12}}$

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1	2	3	4	5
3. Pătrat cu gol simetric	$A = H^2 - h^2$	$z_1 = y_1 = \frac{H}{2}$ $u_1 = v_1 = \frac{H \cdot \sqrt{2}}{2}$	$I_z = I_y = I_u = I_v = \frac{H^2 - h^2}{12}$	$W_z = W_y = \frac{H^4 - h^4}{6H}$ $W_u = W_v = \frac{H^4 - h^4}{6H\sqrt{2}}$ $i_z = i_y = i_u = i_v = \sqrt{\frac{H^2 + h^2}{12}}$
4. Secțiuni compuse simetrice	$A = (B \cdot H - b \cdot h)$	$y_1 = \frac{H}{2}$ $z_1 = \frac{B}{2}$ $z_3 = \frac{B^2 \cdot H - b^2 \cdot h}{2(B \cdot H - b \cdot h)}$	$I_z = I_1 = \frac{B \cdot H^3 - b \cdot h^3}{12}$ $I_{y_1} = I_2 = \frac{B^3 \cdot H - b^3 \cdot h}{12}$ $I_{y_2} = I_2 = \frac{B^3(H - h) + (B - b)^3 h}{12}$ $I_{y_3} = I_2 = I_{y_1} + B \cdot H \cdot \left(z_3 - \frac{B}{2}\right)^2 + b \cdot h \cdot \left(z_3 - \frac{b}{2}\right)^2$	$W_z = \frac{B \cdot H^3 - b \cdot h^3}{6H}$ $W_{y_1} = W_{y_2} = \frac{B^3 \cdot H - b^3 \cdot h}{6B}$ $W_{y_3} = \frac{I_{y_3}}{z_3}$ $i_z = \sqrt{\frac{B \cdot H^3 - b^3 \cdot h}{12(B \cdot H - b \cdot h)}}$
5. Secțiuni compuse simetrice	$A = (B \cdot H + b \cdot h)$	$z_1 = \frac{H}{2}$ $y_1 = \frac{B}{2}$ $z_3 = \frac{b^2 \cdot h + B \cdot H(B + 2b)}{2(B \cdot H + b \cdot h)}$	$I_z = I_1 = \frac{B \cdot H^3 + b \cdot h^3}{12}$ $I_{y_1} = I_2 = \frac{B^3(H - h) + (B + b)^3 h}{12}$ $I_{y_2} = I_2 = \frac{(B + b)^3 H - b^3(H - h)}{12}$ $I_{y_3} = I_2 = \frac{B^3 h + b^3 h}{12} + B H \left(z_3 - \frac{B}{2} - b\right)^2 + b h \left(z_3 - \frac{b}{2}\right)^2$	$W_z = \frac{B H^3 + b h^3}{6H}$ $W_{y_1} = \frac{B^3(H - h) + (B + b)^3 h}{6(B + b)}$ $W_{y_2} = \frac{(B + b)H - b(H - h)}{6(B + b)}$ $W_{y_3} = \frac{I_{y_3}}{z_3}$

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1	2	3	4	5
6. Secțiune dublu T	$A = (Bt_1 + bt_2 + gt)$	$y_1 = y$ $= \frac{Bt_1^2 + bt_2(2H - t_2) + gh(2t_1 + h)}{2(Bt_1 + bt_2 + gh)}$ $y_2 = H - y_1$	$I_y = \frac{B^3t_1 + b^3t_2 + g^3h}{12}$ $I_z = \frac{By_1^3 - (B - g)(y_1 - t_1)^3}{3} + \frac{by_2^3 - (b - g)(y_2 - t_2)^3}{3}$	$W_y = \frac{B^3t_1 + b^3t_2 + g^3h}{6B}$ $W_{z1} = \frac{I_z}{y_1}, \quad W_{z2} = \frac{I_z}{y_2}$ $i_y = \sqrt{\frac{B^3t_1 + b^3t_2 + g^3h}{12(Bt_1 + bt_2 + gh)}}$ $i_z = \sqrt{\frac{I_z}{A}}$
7. Secțiune Z	$A = (BH - bh)$	$e_1 = \frac{H}{2} \left(\cos \alpha + \frac{2B - g}{H} \sin \alpha \right)$ $e_2 = \frac{h}{2} \left(-\sin \alpha + \frac{2B - g}{H} \cos \alpha \right)$ $e_2' = \frac{H}{2} \left(\sin \alpha + \frac{g}{H} \cos \alpha \right)$	$I_z = \frac{BH^3 - bh^3}{12}$ $I_y = \frac{g^3h + 2B^3t}{12} + \frac{Bt}{2}(B - g)^2$ $I_{zy} = -\frac{Bt}{2}(B - g)(H - t)$ $I_1, I_2 = \frac{I_z + I_y}{2} \pm \sqrt{\left(\frac{I_z - I_y}{2} \right)^2 + I_{zy}^2}$ $\alpha_1 = \frac{1}{2} \arctg \frac{2I_{zy}}{I_z - I_y}$	$W_1 = \frac{I_1}{e_1}, \quad W_2 = \frac{I_2}{e_2}$ $i_1 = \sqrt{\frac{I_1}{A}}, \quad i_2 = \sqrt{\frac{I_2}{A}}$ $i_z = \sqrt{\frac{BH^3 - bh^3}{12(BH - bh)}}$
8. Cornier	$A = (BH - bh)$	$z_1 = \frac{B^2H - b^2h}{2(BH - bh)}$ $y_1 = \frac{BH^2 - bh^2}{2(BH - bh)}$ $z_2 = B - z_1, \quad y_2 = H - y_1$ $e_1 = y_1 \cos \alpha + z_2 \sin \alpha$ $e_2 = z_1 \cos \alpha - (y_2 - t) \sin \alpha$	$I_z = \frac{By_2^3 - b(y_2 - t)^3 + gy_1^3}{3}$ $I_y = \frac{Hz_2^3 - h(z_2 - g)^3 + tz_1^3}{3}$ $I_{zy} = \frac{BH}{4}(B - 2z_1)(H - 2y_1) - \frac{bh}{4}(b - 2z_1)(h - 2y_2)$ $\alpha_1 = \frac{1}{2} \arctg \frac{2I_{zy}}{I_z - I_y}$	$W_1 = \frac{I_1}{e_{1 \max}}$ $W_2 = \frac{I_2}{e_{2 \max}}$

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1	2	3	4	5
9. Triunghi	$A = \frac{bh}{2}$	$y_1 = \frac{2}{3}h$ $y_2 = \frac{1}{3}h$	$I_z = \frac{bh^3}{36}$	$W_{z1} = \frac{bh^2}{24}$ $W_{z2} = \frac{bh^2}{12}$ $I_z = \frac{h}{\sqrt{18}}$
10. Romb	$A = \frac{bh}{2}$	$z_1 = \frac{b}{2}$ $y_1 = \frac{h}{2}$	$I_z = I_2 = \frac{bh^3}{48}$ $I_y = I_1 = \frac{b^3h}{48}$	$W_z = \frac{bh^2}{24}, \quad W_y = \frac{b^2h}{24}$ $i_z = \frac{h}{\sqrt{48}}, \quad i_y = \frac{b}{\sqrt{48}}$
11. Trapez	$A = \frac{B-b}{2}h$	$y_1 = \frac{2B+b}{B+b} \cdot \frac{h}{3}$ $y_2 = \frac{2b+B}{B+b}$	$I_z = \frac{B^2 + 4Bb + b^2}{B+b} \cdot \frac{h^3}{36}$ Pentru trapez isoscel $I_y = \frac{h}{48}(B^3 + B^2b + Bb^2 + b^3)$	$W_{z1} = \frac{I_z}{y_1}, \quad W_{z2} = \frac{I_z}{y_2}$ $i_z = \frac{h}{6(B+b)} \cdot \sqrt{2(B^2 + 4Bb + b^2)}$

Anexa 4 (continuare)

1	2	3	4	5
12. Coroana circulară ($k = d/D$)	$A = \frac{\pi D^2}{4}(1 - k^2)$ Inel subțire $A = \pi(D - t)t$ $t = \frac{D - d}{2}$	$z_1 = y_1 = \frac{D}{2}$ $t = \frac{D - d}{2}$	$I_z = I_y = I_1 = I_2 =$ $= \frac{\pi D^4}{64}(1 - k^4)$ $I_z = I_y = \frac{\pi t}{64}(D - d)^3$	$W_z = W_y = \frac{\pi D^3}{32}(1 - k^4)$ $i_z = i_y = \sqrt{\frac{D^2 + d^2}{4}}$ $W_z = W_y = \pi t \frac{(D - t)^3}{4D}$ $i_z = i_y = \frac{D + t}{2\sqrt{2}}$
13. Sector inelar	$A = (R^2 - r^2)\varphi$ Sector de inel subțire $A = 2tR_m\varphi$	$z_0 = \frac{2 \sin \varphi}{3\varphi} \cdot \frac{R^3 - r^3}{R^2 - r^2}$ $z_1 = z_0 - r \cdot \cos \varphi$ $z_2 = R - z_0$ $z_0 = R_m \frac{\sin \varphi}{\varphi}$ $y_1 = R_m \sin \varphi$	$I_z = \frac{R^4 - r^4}{8}(2\varphi - \sin 2\varphi)$ $I_y = \frac{R^4 - r^4}{8} \left(2\varphi - \sin 2\varphi - \frac{32 \sin^2 \varphi}{9\varphi} \right) - \frac{4R^2 r^2 t \sin^2 \varphi}{9(R + r)\varphi}$ $I_2 = \frac{tR_m^3}{2}(2\varphi - \sin 2\varphi)$ $I_y = \frac{tR_m^3}{2} \left(2\varphi + \sin 2\varphi - \frac{4}{\varphi} \sin^2 \varphi \right)$	$W = \frac{R^4 - r^4}{8R} \cdot \frac{2\varphi - \sin 2\varphi}{\sin \varphi}$ $W_{y1} = \frac{I_y}{z_1}, \quad W_{y2} = \frac{I_y}{z_2}$ $i_z = \sqrt{(R^2 - r^2) \frac{2\varphi - \sin 2\varphi}{8\varphi}}$ $i_y = \sqrt{\frac{I_y}{A}}$
14. Segment de cerc	$A =$ $= R \frac{2\varphi - \sin 2\varphi}{2}$	$z_1 = R \sin \varphi$ $y_o = \frac{4}{3} \frac{R \sin^3 \varphi}{2\varphi - \sin 2\varphi}$ $y_1 = R - y_o$ $y_2 = y_o - R \cos \varphi$	$I_y = I_1 = \frac{AR^4}{4} \left(1 - \frac{4 \sin^3 \varphi \cos \varphi}{3(2\varphi - \sin 2\varphi)} \right)$ $I_z = I_2 = \frac{AR^2}{4} \left(1 + \frac{4 \sin^3 \varphi \cos \varphi}{2\varphi - \sin 2\varphi} - \frac{32}{9} \frac{\sin^2 \varphi}{2\varphi - \sin 2\varphi} \right)$	$W_y = \frac{I_y}{z_1}, \quad W_{z1} = \frac{I_z}{y_1}, \quad W_{z2} = \frac{I_z}{y_2}$ $i_y = \frac{R}{2} \sqrt{1 - \frac{4 \sin^2 \varphi \cos \varphi}{3(2\varphi - \sin 2\varphi)}}$ $i_z = \sqrt{\frac{I_z}{A}}$

Anexa 4 (continuare)

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15. Semicoroană circulară	$A = \frac{D^2 - d^2}{8} \pi$	$y_1 = \frac{2}{3\pi} \frac{D^3 - d^3}{D^2 - d^2}$ $y_2 = \frac{D}{2} - y_1$ $z_1 = \frac{D}{2}$	$I_y = I_1 = \frac{D^4 - d^4}{128} \pi$ $I_z = I_2 = \frac{D^4 - d^4}{128} \left(\pi - \frac{64}{9\pi} \right) - \frac{D^2 d^2}{18\pi} \frac{D - d}{D + d}$	$W_y = \frac{\pi D^3}{64} (1 - k^4)$ $W_{z1} = \frac{I_z}{y_1}, \quad W_{z2} = \frac{I_z}{y_2}$ $i_y = \frac{\sqrt{D^2 + d^2}}{4}, \quad i_z = \sqrt{\frac{I_z}{A}}$
16. Coroană eliptică	$A = \pi(ab - a_1 b_1)$	$y_1 = b$ $z_1 = a$	$I_y = I_1 = \frac{\pi}{4} (a^3 b - a_1^3 b_1)$ $I_z = I_2 = \frac{\pi}{4} (ab^3 - a b_1^3)$	$W_y = \frac{\pi}{4a} (a^3 b - a_1^3 b_1)$ $W_z = \frac{\pi}{4b} (ab^3 - a b_1^3)$
17. Hexagon regulat	$A = 1,5R^2 \sqrt{3}$	$y_1 = \frac{R}{2} \sqrt{3}$ $z_1 = R$	$I_z = I_y = I_1 = I_2 = \frac{5\sqrt{3}}{16} R^4$	$W_z = \frac{5}{8} R^3$ $W_y = \frac{5\sqrt{3}}{16} R^3$ $i_z = i_y = R \sqrt{\frac{5}{24}}$